

Claims

1. Lead substitute material for radiation protection purposes in the energy range of an X-ray tube having a voltage of from 60 to 140 kV, wherein for nominal overall lead equivalents of from 0.25 to 2.0 mm the lead substitute material comprises from 12 to 22 wt.% matrix material, from 0 to 75 wt.% Sn or Sn compounds, from 0 to 73 wt.% W or W compounds, from 0 to 80 wt.% Bi or Bi compounds, and wherein not more than one of the constituents is 0 wt.%.
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2. Lead substitute material according to claim 1, **characterised in that** the lead substitute material comprises from 12 to 22 wt.% matrix material, from 0 to 39 wt.% Sn or Sn compounds, from 0 to 60 wt.% W or W compounds, from 0 to 60 wt.% Bi or Bi compounds, and wherein not more than one of the constituents is 0 wt.%.
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3. Lead substitute material according to claim 2, **characterised in that** the lead substitute material comprises from 12 to 22 wt.% matrix material, from 0 to 39 wt.% Sn or Sn compounds, from 16 to 60 wt.% W or W compounds and from 16 to 60 wt.% Bi or Bi compounds.
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4. Lead substitute material according to claim 1,
characterised in that
the lead substitute material comprises
from 12 to 22 wt.% matrix material,
5 from 40 to 60 wt.% Sn or Sn compounds,
from 7 to 15 wt.% W or W compounds and
from 7 to 15 wt.% Bi or Bi compounds.
5. Lead substitute material according to any one of
10 claims 1 to 4,
characterised in that
the lead substitute material additionally comprises up
to 40 wt.% of one or more of the following elements:
Er, Ho, Dy, Tb, Gd, Eu, Sm, La, Ce, Nd, Cs, Ba, I, Pr
15 and/or their compounds and/or CsI.
6. Lead substitute material according to claim 5,
characterised in that
the lead substitute material additionally comprises up
20 to 20 wt.% of one or more of the following elements:
Er, Ho, Dy, Tb, Gd, Eu, Sm, La, Ce, Nd, Cs, Ba, I, Pr
and/or their compounds and/or CsI.
7. Lead substitute material according to claim 6,
25 **characterised in that**
the lead substitute material additionally comprises up
to 8 wt.% of one or more of the following elements:
Er, Ho, Dy, Tb, Gd, Eu, Sm, La, Ce, Nd, Cs, Ba, I, Pr
and/or their compounds and/or CsI.
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8. Lead substitute material according to any one of
claims 1 to 7,

characterised in that

the lead substitute material additionally comprises up to 40 wt.% of one or more of the following elements: Ta, Hf, Lu, Yb, Tm, Th, U and/or their compounds.

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9. Lead substitute material according to claim 8,
characterised in that

the lead substitute material additionally comprises up to 20 wt.% of one or more of the following elements:

10 Ta, Hf, Lu, Yb, Tm, Th, U and/or their compounds.

10. Lead substitute material according to claim 9,
characterised in that

15 the lead substitute material additionally comprises up to 8 wt.% of one or more of the following elements:

Ta, Hf, Lu, Yb, Tm, Th, U and/or their compounds.

11. Lead substitute material for radiation protection purposes in the energy range of an X-ray tube having a voltage of from 60 to 90 kV according to any one of claims 5 to 10,

characterised in that

for nominal overall lead equivalents of from 0.25 to 0.6 mm the lead substitute material comprises

25 from 12 to 22 wt.% matrix material,

from 49 to 65 wt.% Sn or Sn compounds,

from 0 to 20 wt.% W or W compounds,

from 0 to 20 wt.% Bi or Bi compounds and

from 2 to 35 wt.% of one or more of the elements Gd,

30 Eu, Sm, La, Ce, Nd, Cs, Ba, I, Pr and/or their compounds and/or CsI.

12. Lead substitute material according to claim 11,
characterised in that
the lead substitute material comprises from 2 to
25 wt.% I, Cs, Ba, La, Ce, Pr and/or Nd and/or their
5 compounds and/or CsI.
13. Lead substitute material for radiation protection
purposes in the energy range of an X-ray tube having a
voltage of from 100 to 140 kV according to any one of
10 claims 5 to 10,
characterised in that
for nominal overall lead equivalents of from 0.25 to
0.6 mm the lead substitute material comprises
from 12 to 22 wt.% matrix material,
15 from 40 to 73 wt.% Bi and/or W or their compounds and
from 5 to 38 wt.% of one of more of the following
elements: Gd, Eu, Er, Hf and/or their compounds.
14. Lead substitute material according to any one of
20 claims 1 to 13,
characterised in that
it comprises a structure of protective layers of
different compositions.
- 25 15. Lead substitute material according to claim 14,
characterised in that
it comprises a structure of at least two protective
layers of different compositions which are separate or
joined together, wherein the protective layer(s) more
30 remote from the body comprise(s) predominantly the
elements having a lower atomic number, or their
compounds, and the protective layer(s) close to the

body comprise(s) predominantly the elements having a higher atomic number, or their compounds.

16. Lead substitute material according to claim 14 or 15,
5 **characterised in that**
it comprises a structure of at least two protective layers of different compositions which are separate or joined together, wherein at least in one layer at least 50% of the total weight consists of only one
10 element from the group Sn, W and Bi or their compounds.
17. Lead substitute material according to claim 14 or 15,
15 **characterised in that**
it comprises a structure of at least two protective layers of different compositions which are separate or joined together, wherein at least in one layer at least 50% of the total weight consists only of at least 40 wt.% Sn or its compounds and at least 10 wt.%
20 I, Cs, Ba, La, Ce, Pr and/or Nd and/or their compounds and/or CsI.
18. Lead substitute material according to claim 14,
25 **characterised in that**
it comprises a structure of at least two protective layers of different compositions which are separate or joined together, wherein the protective layer(s) more remote from the body comprise(s) predominantly the elements or their compounds having a higher X-ray
30 fluorescent yield, and the protective layer(s) close to the body comprise(s) the elements or their compounds having a lower X-ray fluorescent yield.

19. Lead substitute material according to any one of claims 14 to 18,

characterised in that

5 it comprises a structure of at least three protective layers of different compositions which are separate or joined together, wherein the protective layer(s) more remote from the body and the protective layer(s) close to the body comprise predominantly the elements having
10 a higher atomic number or their compounds, and there is arranged in the middle at least one protective layer comprising predominantly elements having a lower atomic number.

15 20. Lead substitute material according to any one of claims 14 to 20,

characterised in that

a weakly radioactive layer is embedded between two non-radioactive protective layers which are separate
20 from or joined to the radioactive layer.

21. Lead substitute material according to any one of claims 1 to 20,

characterised in that

25 the metals or metal compounds are granular and their particle sizes exhibit a 50th percentile according to the following formula

$$D_{50} = \frac{d \cdot p}{10} mm$$

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wherein

D_{50} represents the 50th percentile of the particle size distribution,

d represents the layer thickness in mm and

p represents the proportion by weight of the

5 particular material component in the total weight,

and the 90th percentile of the particle size

distribution $D_{90} \leq 2 \cdot D_{50}$.

22. Radiation protection apron of lead substitute material
10 according to any one of claims 1 to 21.